TECHNICAL REPORT
76-49-CEMEL

THE EFFECTS OF TROPICAL AND LEATHER COMBAT BOOTS ON LOWER EXTREMITY DISORDERS AMONG US MARINE CORPS RECRUITS

by

C. K. Bensel

March 1976

UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

Clothing, Equipment & Materials Engineering Laboratory

CE&MEL-154

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TR 76–49–CEMEL	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* THE EFFECTS OF TROPICAL AND LEATHER COMBAT BOOTS ON LOWER EXTREMITY DISORDERS AMONG US MARINE CORPS RECRUITS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER CEMEL 154
7. AUTHOR(s) Carolyn K. Bensel		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Clothing, Equipment and Materials Engineering Laboratory US Army Natick Research & Development Command Natick, MA 01760		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 1Y762716AH70-02, O&MA
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Natick Research & Development Command Natick, MA 01760		12. REPORT DATE March 1976 13. NUMBER OF PAGES 63
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

BOOTS	TROPICAL COMBAT BOOT	FOOTWEAR TECHNOLOGY
COMBAT BOOT	PROTECTIVE CLOTHING	RECRUITING
FOOTWEAR	DISORDERS, FOOT	MILITARY FORCES (UNITED STATES)
WARFARE	FOOT	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A study was conducted among 12 recruit platoons at the US Marine Corps Recruit Depot, San Diego, California, to determine whether the use of tropical combat boot during training would significantly reduce the number of cases of lower extremity disorders compared to the number occurring when the leather combat boot was worn. To accomplish this, each of the 12 platoons was randomly divided into two footwear groups and approximately one-half of a platoon was issued tropical and the other half leather combat boots. Each recruit wore the boots issued to him throughout the twelve weeks of training. Podiatrists examined the feet of all test

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

participants on four specified occasions over the course of training and noted any foot problems. These data were augmented by the diagnostic information generated from sick call visits made for lower extremity disorders. Separate chi-square analyses were performed on each of the 17 categories of foot problems diagnosed among the 879 recruits who completed this study. It was determined that the number of cases of heel contusions, toe paresthesia, and retrocalcaneal bursitis were significantly increased through the use of tropical boots and plantar fasciitis through the use of leather combat boots. Relationships between foot disorders and certain body structures were also analyzed, as were the number of sick call visits made as a function of training week and the impact of lower extremity disorders on Marine Corps recruit training schedules.

PREFACE

The study reported here was a joint effort by personnel of the US Marine Corps, the US Navy, and the US Army. Each representative of these Services provided a particular expertise required in the conduct of the study. Naval podiatrists and their staffs assigned to the Marine Corps Recruit Depot (MCRD), San Diego, and to the Marine Corps Base, Camp Pendleton, were responsible for all medical aspects, including foot examinations of all test participants. Personnel of the US Army Natick Research and Development Command (NARADCOM) prepared the test plan and final report and conducted the activities related to footwear technology. The MCRD Clothing Officer and his staff controlled and distributed the footwear. The Officers and Drill Instructors of the Recruit Training Regiment, MCRD, executed the test. All aspects of these activities were coordinated by the Project Officer, Marine Corps Development Center, Quantico, the Marine Corps Liaison Officer, NARADCOM, and the NARADCOM Project Officer.

Although the risk of failing to cite the invaluable contributions of the many people involved is great, the author of this report wishes to express her appreciation to the following persons who were responsible for the successful completion of this effort:

L/GEN J. C. Fegan, Jr., USMC, Commanding General, MCRD

COL G. W. Rodney, USMC, Chief of Staff, MCRD

L/COL J. G. Collier, USMC, Executive Officer, Regruit Training Regiment, MCRD

MAJ R. J. Gruenberg, USMC, and CPT R. S. Taylor, USMC, Regimental S-4, Recruit Training Regiment, MCRD

LT M. V. Ruggiero, USMC, Clothing Officer, MCRD

Officers and Drill Instructors, Recruit Training Regiment, MCRD

L/CDR K. Scott, USN, MSC, Podiatrist, Marine Corps Base, Camp Pendleton

LT C. R. George, USN, MSC, Podiatrist, MCRD

L/COL W. R. Belcher, USMC, Marine Corps Liaison Officer, NARADCOM

MAJ D. A. Crowe, USMC, Project Officer, Marine Corps Development Center, Quantico

Mr. D. S. Swain, Project Officer and Clothing Designer (Footwear), Clothing, Equipment, & Materials Engineering Laboratory, NARADCOM

Mr. R. F. Lacerte, Chemist (Leather), Clothing, Equipment, & Materials Engineering Laboratory, NARADCOM

Mr. R. I. Cargill, Clothing Designer (Footwear), Clothing, Equipment, & Materials Engineering Laboratory, NARADCOM

Mr. M. J. Longval, Psychology Aid, Clothing, Equipment, & Materials Engineering Laboratory, NARADCOM

Ms. M. E. Flood, Psychology Aid, Clothing, Equipment, & Materials Engineering Laboratory, NARADCOM

Funding for this study was provided by and to the Clothing, Equipment, & Materials Engineering Laboratory, NARADCOM, under the following requests for services, jobs, and projects:

Evaluate Tropical Boots at Marine Corps Depot, San Diego – A Joint USMC/NARADCOM Effort. MIPR No. M95450–5–7702.

Technical and Engineering Services in Support of US Marine Corps. NARADCOM O&MA–728012.12000.

Army Human Factors Engineering, Man/Environment Compatibility – Human Factors Analysis in Support of Materiel Research and Development. NARADCOM Project No. 1Y762716AH70–02.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THE EFFECTS OF TROPICAL AND LEATHER COMBAT BOOTS ON LOWER EXTREMITY DISORDERS AMONG US MARINE CORPS RECRUITS

INTRODUCTION*

The feet of the military man are a principal and enduring concern. As early as the reign of Valentine II (375-393 A.D.), Vegetius published a treatise on military science describing desirable physical characteristics of the young recruit in which he stated that the recruit should have thighs, calves, and feet "hard with accumulated muscle".[1] Cold injury to the feet has become one of the most widely recognized major medical problems encountered in military campaigns throughout history.[2] In peacetime, there is also a high frequency of foot disorders in the military population, particularly among recruits experiencing, for the first time, prolonged periods of marching, the use of military footwear, and the general rigors of training.[3]

Perhaps because they seldom occur outside the military environment and can potentially prevent a man from performing his normal duties for a prolonged period of time, stress fractures, also known as march or fatigue fractures, have been studied widely by medical personnel responsible for treating foot disorders in the military.[4] The most common sites of the fracture seem to be the metatarsals and the calcaneus,[5,6,7] but there

---

*Descriptions of the foot disorders cited in this and other sections of the report are presented in Appendix A.

[1] Moxness, B. A. Military medicine and care of the war disabled to World War I. *Military Medicine*, 1956, **121**, 180–181.

[2] Bell, L. G., Shalgren, L. H., and Sheren, B. D. Frostbite in Koreancasualties. *US Armed Forces Medical Journal*, 1952, 35–40.

[3] Dalany, H. M. and Travis, L. O. A clinical evaluation of one hundred cases of infection of the lower leg and foot in military personnel. *Military Medicine*, 1965, **130**, 1184–1190.

[4] Lanham, R. H. Stress fractures in military personnel. *Journal of the American Podiatry Association*, 1963, **53**, 192–195.

[5] Allen, T. S. Stress fractures. *Texas Medicine*, 1972, **68**, 125–128.

[6] MacDonald, R. G. Early diagnosis and treatment of stress fractures of the calcaneus. *Journal of the American Podiatry Association*, 1966, **56**, 533–536.

[7] O'Donnell, T. Medical problems of recruit training: A research approach. *US Navy Medicine*, 1971, **58**, 28–34.

are some indications that the frequency of fracture at a given site varies among the military services.[8] The time and rate of occurrence of stress fractures may also vary among the military services as a function of their respective training regimens. Allen (reference 5) and MacDonald (reference 6) reported that, among Army recruits, they generally occur within the first two weeks of basic training. Hockstein[9] estimated that stress fractures among Naval trainees occurred in the third and fifth training weeks, the most active phases of training. For Marine recruits at Parris Island, O'Donnell (reference 7) found that stress fractures generally occurred within the first three weeks, but could occur as late as the sixth or the eighth week of training.

With regard to rate of occurrence, stress fractures accounted for 1.1% of the cases seen by podiatrists in 1.5 years at the Great Lakes Naval Training Center,[10] whereas 3% of all Marine Corps recruits trained in a year at Parris Island incurred stress fractures (reference 7). Gilbert and Johnson (reference 8) attributed such differences in rate of occurrence to the many more hours of physical exercise and drill experienced by Marine Corps recruits and to the particular march pattern used by the Marines of "digging in the heel". Gilbert and Johnson also attemped to relate stress fractures to body structure and found that the fractures were more common among obese recruits and those with little athletic experience. No relationship with foot structure or type could be firmly established.

Stress fractures are only one of the foot disorders affecting the military population in general and recruits in particular. In an evaluation of lower extremity infections among 100 military personnel admitted to the Army hospital at Fort Dix, New Jersey, Delany and Travis (reference 3) found that 78% of the patients were in the first four weeks of basic training and 18% were in the last four weeks. Ulcers attributable to abrasion of broken blisters accounted for 52% of the foot problems, blisters 21%, and cellulitis 21%. The latter generally involved the anterior aspect of the upper dorsum and the Achilles region of the foot. The length of hospital stay for these disorders varied from 2 to 25 days, with the mean being 6.45 days.

Data available from the Great Lakes Naval Training Center substantiate the high percentage of recruit foot disorders. Hockstein (reference 9) estimated that six out of every 100 Naval trainees have foot complaints of such severity that the men are referred

---

[8] Gilbert, R. S. and Johnson, H. A. Stress fractures in military recruits – A review of twelve years' experience. *Military Medicine*, 1966, **131**, 716–721.

[9] Hockstein, E. S. The role of the podiatrist in the Naval Service. *Journal of the American Podiatry Association*, 1961, **51**, 488–492.

[10] Schnitzer, J. S. and Hoeffler, D. F. The distribution and etiology of foot disorders in a Navy recruit population. *Journal of the American Podiatry Association*, 1974, **64**, 845–853.

to a podiatrist. About 30% of all these sick calls are for such problems as foot strain, synovitis, metatarsalgia, and tendinitis, 10% for corns and calluses, and 20% for ingrown nails. The remaining 20% are traumatic complaints such as sprains and fractures.

As an update and an extension of Hockstein's findings (reference 9), Schnitzer and Hoeffler (reference 10) further evaluated the foot disorders found among recruits at the Great Lakes Naval Training Center. Over a period of 1.5 years, approximately 26% of all recruits reported to the podiatry clinic with foot-related complaints. Approximately 65% of these complaints were attributed to a structural or mechanical abnormality of the foot such as pes planus, hallux valgus, hammer or mallet toes, and pes cavus. These were experienced by 25, 12, 12, and 2% of the recruits seen, respectively. Dermatologic problems accounted for 30% of all disorders, and traumatic injury for 5%.

Based upon the information presented above, there can be little doubt that disorders of the lower extremities among the military are costly in terms of medical personnel, hospital and clinic facilities, and recruit training time lost for sick calls, hospitalization, and other duty restrictions. The solution to the problem is not clear-cut, in part because of the many situational variables which may be contributing to the problem. Preventive programs which include thorough pre-enlistment screening, proper fitting of footwear, instruction of recruits and their superiors in foot hygiene, and early identification and proper treatment of foot disorders are, of course, an important first step (reference 3; reference 10). Modification of recruit training programs is also a potential means of reducing the occurrence of lower extremity disorders. However, because of the impact this may have on achieving the necessary state of military readiness, it is not an attractive solution. Another alternative is to develop footwear, the use of which will result in a significant decrement in foot disorders. Since information is not available to directly relate a specific foot disorder to a specific footwear design characteristic, much less to prove that an alternate design will reduce foot problems, this solution is not as easily achieved as one may think. The study reported here is an attempt to acquire some basic information regarding foot problems as they relate to footwear, and particularly combat boot, design.

The combat boots authorized for issue to all military services today, and worn daily during Marine and Army basic training, are made over the Fort Knox V Last which was introduced into military boot design in the early 1960's. Prior to that time, Army boots were made over the Munson Last and Marine boots over a commercial last. The Munson Last was an inflare type. Both lasts required that a large tariff of shoe sizes be stocked to accommodate the population. The Army boot was stocked in 56 sizes and the Marine boot in 90 sizes.[11] The goals in developing the Fort Knox V Last were to produce a last which conformed to the mean anthropometric dimensions of the American male

[11] Perkins, J. C. Quartermaster Field Evaluation Agency Tech. Report T-192, June 1961.

foot, to reduce the tariff of sizes required, and to generate a single last acceptable to all military services.[12]

The Fort Knox V Last was initially tested by the Army using boots of a welt construction in which the sole components were machine-stitched to the shoe upper and the heel was nailed to the sole. Test boots were produced over the new last both with and without pronation devices. The insertion of the pronation device was based upon the Schwartz principle, advanced by the Myodynamics Laboratory of the University of Rochester, which involved the theory that pronation is prevalent in most people, that it causes early fatigue, and that it can be relieved by providing additional support on the inner border of footwear.[13] Initially, boots made over the Fort Knox V Last were tested at Forts Lee, Devens, and Benning for fit and to determine whether or not there were any clinical effects during periods of extended wear.[14,15] Over 2000 Army infantry troops were fitted with and wore the boots for up to eight weeks while involved in typical field training. The feet of the participants were examined by medical personnel prior to boot issue and at weekly intervals thereafter.[16] Based upon the data obtained, it was concluded that 99% of the test participants were successfully fitted and probably could have been fitted in whole sizes alone (reference 14; reference 15). The clinical findings revealed no aggravation of lower extremity disorders (reference 16). It was further determined that the pronation device should be eliminated from consideration.

A more extensive test of the Fort Knox V Last was conducted jointly by the Marine Corps and the Army in which four types of boots were compared with regard to fit and wearability (reference 11). These were:

a. Standard Army boot of flesh-in leather made over the Munson Last – 56 sizes

b. Standard Marine Corps boot of flesh-out leather made over the Marine Last – 90 sizes

---

[12] Potter, W. A. Report on Department of Defense research project relative to combat boots made over a new type of last. *Journal of the American Podiatry Association, 1961,* 51, 493–497.

[13] Allen, V. L. and McGinnis, J. M. Quartermaster Research & Development Center Research Study Report PB-8, January 1957.

[14] Perkins, J. C. Quartermaster Field Evaluation Agency Tech. Report 55007-F, April 1956.

[15] Perkins, J. C. Quartermaster Field Evaluation Agency Tech. Report T-88, November 1958.

[16] Ulmer, D. D. and Stein, S. W. US Army Medical Research Lab Tech. Report MEDEA-RD-58-37, January 1958.

c. Standard Army boot made over the Fort Knox V Last – 29 whole sizes, no half sizes

d. Standard Marine boot made over the Fort Knox V Last – 29 whole sizes, no half sizes

The test participants were over 800 Marines stationed at Camp Lejeune and in Puerto Rico and over 900 Army infantry and airborne troops at Forts Bragg and Benning. The feet of all participants were examined by medical personnel and each man was issued one type of boot which he wore for four weeks. A foot examination followed the wear period and each man was then issued another type of boot. This procedure was followed until each man had worn all four boot types. The findings indicated that either the Marine or the Army combat boot made over the Fort Knox V Last was more comfortable and created fewer foot problems than did those boots made over the old lasts.[17] There was a higher percentage of foot problems when the Marine boot was worn and this finding was attributed to the rough-side-out leather of the boot. Based upon this study, it was recommended that combat boots for both the Army and the Marine Corps be made over the Fort Knox V Last in a tariff of 29 sizes, that boot height be reduced by 3.81 cm, and that the toe cap of the boot be eliminated (reference 11).

Since the adoption of the Fort Knox V Last by the Marine Corps and the Army, all military services have used identical leather combat boots with a grain-out, leather upper, rigid toe plate without a toe cap, and a leather counter pocket on the outside. The vast majority of boots produced today are no longer of a welt construction, but rather a method of vulcanization is now used to produce boots with direct molded soles.[18] Half sizes have been added to the tariff since the boot was adopted, along with additional whole sizes and widths.

The genesis of the study to be presented here was a letter dated 7 February 1973, from the Commanding General, Marine Corps Recruit Depot, San Diego, California, to the Commanding General, Marine Corps Supply Activity, Philadelphia, Pennsylvania, in which it was reported that deficiencies were suspected in the leather combat boot and that recruits were experiencing lower extremity disorders which may be related to these

---

[17] Potter, W. A. Final report on Department of Defense research project relative to combat boots made over a new type of last. *Journal of the American Podiatry Association,* 1962, 52, 122-125.

[18] Park, A. F. and Swain, D. S. US Army Natick Laboratories Tech. Report 68–20–CM, September 1967.

deficiencies. CDR Richard S. Gilbert, USN, MSC, Depot Podiatrist at San Diego, proposed that a boot already in the military supply system, the tropical combat boot, be studied as a possible means of reducing foot problems. In a message dated 21 November 1974, the Commandant, US Marine Corps, authorized direct liaison between the Marine Corps Recruit Depot and the US Army Natick Research and Development Command, Natick, Massachusetts, the primary developer of military footwear, to plan and conduct a test involving the tropical combat boot.

The tropical boot, as the name implies, is used in high temperature- high humidity environments (23.9–37.8°C, 63–100% R.H.). It was developed to withstand the heat, moisture, and fungal deterioration encountered in jungles and to provide troops with a quick-drying, well-ventilated boot having water drainage and spike protection capabilities. Reports from men who used this boot in Southeast Asia were highly favorable (reference 18). The tropical boot is made over the Fort Knox V Last and has a leather vamp and counter pocket and a direct molded sole, as does the leather. However, the counter is less rigid and the uppers of the tropical boot are made of a cotton/nylon blend and have a nylon tape up the back and around the top. The cotton duck material is softer and more flexible than a leather upper.

CDR Gilbert hypothesized that cellulitis among Marine Corps recruits may be attributable to the stiffness of the leather boot counter and Achilles tendinitis to its rather rigid backstay. He maintained that the softer counter of the tropical boot and its more flexible backstay may decrease the instances of both of these disorders (Note 1). Among the other recruit foot problems seen frequently by CDR Gilbert were stress fractures and clinical stress fractures. He suggested that any study of the use of the tropical boots by Marine Corps recruits also focus on these disorders (Note 1). On the basis of these hypotheses, the present study was designed to investigate the effects of the wearing of the tropical boot on these lower extremity disorders. Specifically, the purposes of this study were:

a. To determine whether the use of the tropical combat boot during Marine Corps recruit training would significantly reduce the number of cases of cellulitis and Achilles tendinitis compared to the number of cases occurring when the leather combat boot was worn.

b. To analyze the effects of these two types of boots on other, frequently-developed disorders of the feet.

Note 1: Gilbert, R. S. Personal communication, December 16, 1974.

c. To document the frequency of occurrence of various foot disorders among Marine Corps recruits in order to obtain baseline data for further research efforts on footwear.

d. To investigate relationships among body structures and foot disorders.

METHOD

Participants

The test participants were 990 men who began Marine Corps recruit training at the US Marine Corps Recruit Depot, San Diego, California, during the week of 22 June 1975. These men were members of three recruit training series, designated as 1069, 2069, and 3069. Each series was comprised of four platoons, designated as 69 through 72. Thus, one series from each of three active recruit training battalions was included insuring, as much as possible, a true cross-section of the training environment. For the purposes of this study, each platoon within a series was randomly divided into two footwear groups and approximately one half of a platoon was issued tropical combat boots, and the other half leather combat boots.

Description of Combat Boots

The tropical combat boot (Boot, Combat, Tropical w/Integral Spike Protection), made over the Fort Knox V Last, has a black leather, plain toe vamp and counter pocket (Figure 1). The leather is treated with silicone for water-proofing. The uppers have a full, lace closure system and are of a cotton/nylon blend with a 2.54-cm wide, nylon tape up the back and around the top and a 5.08-cm wide, nylon webbing diagonally across the ankle. The leather insole is split into two pieces and a 0.28-cm thick, stainless steel plate is inserted between the pieces and stitched around the periphery for spike protection. The rubber outsole is direct molded to the upper. The boot is available in full sizes ranging from 4 to 14 and five widths (extra narrow, narrow, regular, wide, and extra wide). The soles of the tropical boots issued in this study were of two different styles, a Panama and a standard (Figure 2). The latter is a commercial lug-type sole, the traction of which is sometimes diminished by mud and clay which clings to the cleats and by small rocks which lodge between them.[19] The Panama is patterned after the heavy treads on military vehicles to allow quick release of mud, pebbles, and other debris. Each boot is issued with Saran inserts which may be retained or removed at the wearer's discretion.

The leather combat boot (Boot, Combat, Leather, Black, Direct Molded Sole), made over the Fort Knox V Last, has a full, lace closure system, grain-out leather upper, plain toe vamp, removable Saran inserts, and an outside leather counter pocket. The leather is treated with silicone for water-proofing. The rubber outsole is direct molded to the upper and consists of a full, transverse chevron, outer sole and heel (Figure 3). The

---

[19] Sims, C. U.S. Army Tropic Test Center USATECOM Project No. 8-6-6010-01, August 1966.

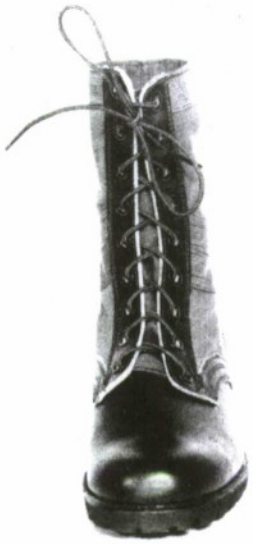

Figure 1a. Front view of tropical combat boot.

Figure 1b. Side view of tropical combat boot.

Figure 1c. Rear view of tropical combat boot.

Figure 2. Sole tread designs of the stantard (left) and the Panama (right) tropical combat boots.

Figure 3. Sole tread design of the leather combat boot.

boot is available in full and half sizes from 4 to 14 and five widths (extra narrow, narrow, regular, wide, and extra wide). Two styles of leather combat boots were included in this study, the standard and an improved version (Figure 4). These boots differ in counter design. The standard has a piece of leather for the backstay and another for the counter pocket which are overlapped. The improved has a one piece, combined backstay and counter pocket.

Data Acquisition Forms

Two forms were devised for use in this study to insure that all relevant data were obtained regarding the occurrence of foot problems among the test participants. These were Individual Record Sheets and Sick Call Stamps (Appendix B). The former were issued to each recruit participating in the study. They were placed in his file and remained there for the duration of the study. The recruit's name and platoon were entered on the sheet along with the type, style, and size of boot issued to him, the results of foot examinations, and a listing of his attendance at sick calls for foot-related problems. Sheets were numbered from 1 to 1000 in the upper left corner. Those recruits receiving odd-numbered sheets were to be issued leather combat boots, while those receiving even-numbered sheets were to be issued tropical boots.

The Sick Call Stamp (Appendix B) was a rubber stamp with a listing of the foot problems of particular interest in this study and a space for comments. This stamp was to be imprinted on the back of each Sick Call Slip (Form 11ND-MCRD-6150/3) issued to a test participant. If the sick call was related to foot problems, the attending medical personnel so indicated on the back of the Sick Call Slip together with the diagnosis and relevant descriptive information. The date of the sick call and the disposition of the problem were entered on the front of the slip. The Sick Call Slip was then returned to the test participant's file. The information on it related to foot problems was entered on the Individual Record Sheet and the slip was retained in the file for the duration of the study.

Procedure

Prior to test initiation, officers and drill instructors of the Recruit Training Regiment were briefed with regard to the purposes of the test, test procedures, and their specific test-related responsibilities. They were instructed to follow normal procedures in training, boot break-in, and lacing method, regardless of the boots their men were wearing. Individual Record Sheets and Sick Call Stamps were distributed to those drill instructors responsible for the 12 platoons of test participants. Additional Sick Call Stamps were distributed to company commanders throughout the regiment so that data could be maintained on test participants transferred from their original series during the course of training. The Regimental S-4 was appointed as the on-site test coordinator and served as the point of contact between the series commanders and the Marine Corps Development Center project officer for the study.

Figure 4a. Front views of the standard (left) and the improved (right) leather combat boots.

Figure 4b. Side views of the standard (left) and the improved (right) leather combat boots.

Figure 4c. Rear views of the standard (left) and the improved (right) leather combat boots.

The formal initiation of the study occurred on the day each recruit was issued his first pair of combat boots to replace his civilian shoes, which he had worn until this time (Figure 5). Boot distribution was conducted during the five processing days which preceded the start of training and extended from 24 through 27 June 1975. The lower extremities of each test participant were first examined by the podiatrist assigned to the Marine Corps Recruit Depot (Figure 6). He noted foot problems, the presence of certain body structures, and any history of lower extremity disorders on each recruit's Individual Record Sheet and signed the sheet to indicate that Exam 1 had been conducted. The recruit, wearing cushionsoled socks, was then fitted with one pair of either the tropical or the leather combat boot. The fitting was accomplished by the supply personnel of the Depot according to their standard procedure of using a Foot Measuring Device, Men's (MIL-F-43782) for initial sizing, followed by visual inspection of the fit, with resizing as required (Figure 7). The determination of the type of boot to be issued to a recruit was made on the basis of the number on his Individual Record Sheet. Odd numbers denoted leather and even numbers denoted tropical combat boots.

In the event that a proper fit could not be achieved in the tropical boot, which was available only in full sizes, a recruit was fitted with and issued the leather boot in an appropriate half size. He was then replaced by a recruit from the same platoon who was to have received a leather boot, but who could be fitted in a full size tropical boot. In this way, an approximately equal distribution of both types of boots was achieved within a platoon. No attempt was made to issue an equal number of Panama design soles and standard soles in the tropical boots or of standard and improved leather boots. Therefore, with regard to distribution of the first pair of boots, only the type of boot, leather or tropical, was considered. However, after each recruit received his boots, the size, the type, and the particular style of boot issued were entered on his Individual Record Sheet.

Each test participant was issued a second pair of boots approximately five days after he had received the first pair. This event occurred between the second and fourth days of formal training. Following standard procedures, those recruits stating that the initial pair of boots had not fit properly were resized before being issued a second pair. These boots were to be of the same type and style as the first, provided a proper fit could be achieved within the size ranges of boots available. The remaining recruits were not resized and received a second pair of boots of the same type and particular style as the first, again provided that they could be properly fitted from the available stock of boots. The size and type of the second pair of boots were entered on the Individual Record Sheet, together with the particular boot style.

In addition to the foot examination of all test participants prior to boot issue (Exam 1), there were three other exams conducted by podiatrists over the course of testing. The second examination (Exam 2) occurred at the completion of the prescribed 15-mile

Figure 5. Recruits in civilian footwear prior to being issued combat boots.

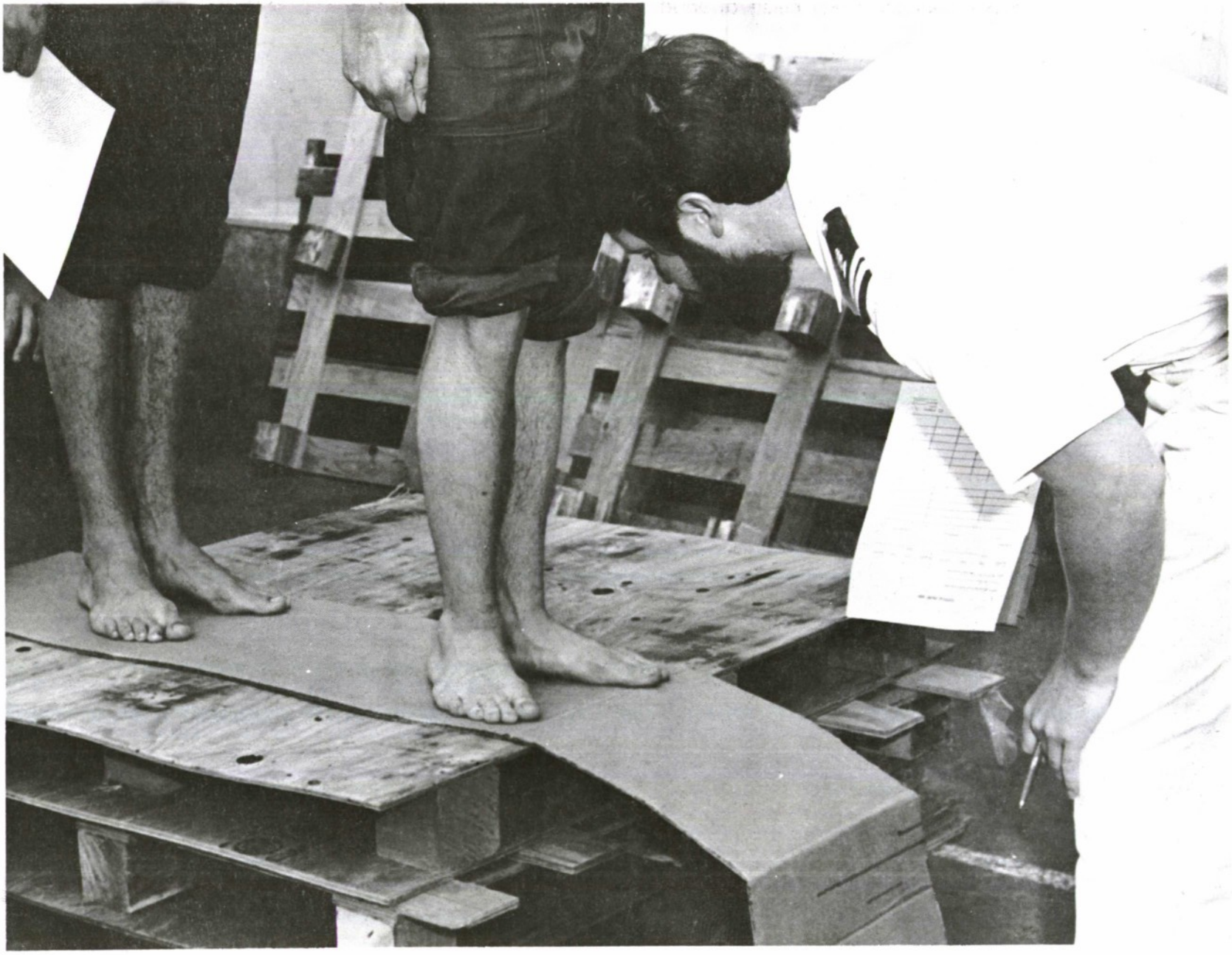

Figure 6. Examination of the feet of test participants prior to the issuing of combat boots.

Figure 7. Initial sizing for combat boots using a Foot Measuring Device, Men's.

hike during the fifth week of training (approximately the thirtieth training day). Exam 3 occurred during the eighth week of training upon return from Infantry Training School (approximately the fifty-third training day). Both Exams 2 and 3 took place at Camp Pendleton under the supervision of the podiatrist assigned to the medical facility there. The fourth and final examination (Exam 4), conducted during the twelth week of training, signified the completion of the study and was held on approximately the seventy-fourth day of the 77-day training cycle. Exam 4 occurred during the week of 14 September 1975. The Individual Record Sheets and Sick Call Slips were retrieved from the recruits at this time.

The procedure for each of the foot examinations was the same as that described above for Exam 1. The podiatrist examined the feet of each test participant for indications of tendinitis, cellulitis, and other foot problems. The Individual Record Sheet was completed to denote the occurrence of each exam and the presence of foot disorders, if any.

Sick call data were used to augment the information acquired during the four scheduled foot examinations. When a test participant requested to report for sick call, the Sick Call Stamp was imprinted on the back of the Sick Call Slip. If the reason for attending sick call was foot related, the attending medical personnel completed the appropriate portion of the back of the Sick Call Slip including the diagnosis and any relevant observations. The front of the slip contained the date of the sick call and the disposition of the case including instructions for limitations of the recruit's activities, follow-up appointments, or the use of special footwear. The information on the slip was entered on the Individual Record Sheet and the Sick Call Slip was then placed in the recruit's file.

All training of recruits participating in this study followed the normal procedures. Each recruit wore the boots issued to him when combat boots were the specified footwear for a given activity. If a recruit was reassigned during the course of testing to a platoon not originally involved in the study, he continued as a study participant. His Individual Record Sheet was transferred and maintained along with Sick Call Slips and he was sent for foot examinations at the specified points in his training schedule. Testing was terminated during the week of 14 September 1975, for all recruits, including those who had been transferred from their original platoons and experienced slippages in their training schedules.

RESULTS

Overview of Recruit Data

Individual Record Sheets were received for 879 (89%) of the 990 recruits who began the test. These men had either completed training with their original platoons (Graduates), been transferred during training to different platoons (Stragglers), or been separated from the Marine Corps prior to training completion (Dropouts). The Stragglers, due to loss of training time or a repetition of certain phases of training, had not completed the entire program by the time testing was terminated. However, they had been given at least three foot examinations. Table 1 is a listing by platoon of the number of original participants in the study and the number of Individual Record Sheets received for analysis. The percentages are based upon the original number of participants. Table 2 is a listing by original platoon of the number of recruits, including Graduates, Stragglers, and Dropouts, who could be positively identified, on the basis of Individual Record Sheets received, as having been issued two pairs of leather boots of either style or two pairs of tropical boots of either style. The totals over all platoons were 414 recruits with leather and 372 with tropical combat boots. The total number of men within a platoon who could be identified as having received two pairs of boots of identical type **and** style is also included in Table 2. It can be seen here that the standard leather and the Panama tropical were the most widely issued boots with 216 recruits being identified as having received two pairs of the former and 290 recruits two pairs of the latter.

A listing by platoon of the more common body structures and history of lower extremity disorders identified during Exam 1 and their number is presented in Table 3. The table entries for each platoon include Graduates, Stragglers, and Dropouts. The percentages were computed using the total number of data sheets received from a platoon (Table 1). The category of ankle fracture and/or sprain is a tally of the number of recruits reporting the occurrence of an ankle or foot fracture within the previous four years, a recent ankle sprain, or a history of chronic ankle sprain. Next to pes planus, this category included the highest percentage of recruits. Table 4 is a similar listing of the foot problems diagnosed during sick calls or identified during Exams 2, 3, or 4. No Exam 1 findings are included. The entries are the number and percentage of men within a platoon (Graduates, Stragglers, and Dropouts) who were identified at least once as having a particular problem. The percentages were calculated as in Table 3. Problems 1 through 6 are those upon which this study focused, while 7 through 17 are additional problems identified among the recruits over the course of the study. These latter items are foot problems which occurred in more than one instance. They have been included in this study in order to provide as complete a record as possible of the types of foot problems encountered among Marine Corps recruits at San Diego. The most common disorder was blisters, identified in 33.56% of the men, followed by heel contusions and lace irritation, diagnosed in 11.26 and 12.06% of the recruits, respectively. Almost 3% of the test

TABLE 1

Original Number of Study Participants and Number of Data Sheets Received

Platoon	Original no.	Graduates	Stragglers	Dropouts	Total
1069	71	60(85%)	3	2	65
1070	75	65(87%)	1	0	66
1071	90	74(82%)	3	2	79
1072	90	74(82%)	3	3	80
Series Total	326	273(84%)	10	7	290(89%)
2069	84	48(57%)	17	14	79
2070	85	45(53%)	25	5	75
2071	86	62(72%)	13	5	80
2072	80	49(61%)	17	6	72
Series Total	335	204(61%)	72	30	306(91%)
3069	85	71(84%)	7	0	78
3070	76	58(76%)	7	0	65
3071	83	59(71%)	11	0	70
3072	85	60(71%)	9	1	70
Series Total	329	247(75%)	34	1	282(86%)
Grand Total	990	725(73%)	116	38	879(89%)

TABLE 2

Number of Recruits in Each Platoon Issued Two Pairs of Boots of Identical Type or Identical Type and Style

Platoon	Boot Type[a]		Boot Type and Style[b]			
	L	T	Std. L	Imp. L	Std. T	PT
1069	34	21	1	0	0	3
1070	34	32	22	12	6	26
1071	36	40	23	3	2	27
1072	36	22	26	5	0	21
Series Total	140	115	72	20	8	77
2069	30	24	16	14	1	23
2070	32	31	20	6	0	31
2071	35	30	0	3	0	1
2072	37	35	21	8	0	25
Series Total	134	120	57	31	1	80
3069	37	42	20	14	0	41
3070	32	33	15	14	0	32
3071	35	30	25	7	1	29
3072	36	32	27	5	1	31
Series Total	140	137	87	40	2	133
Grand Total	414	372	216	91	11	290

[a]L=Leather, T=Tropical

[b]Std. L = Standard Leather, Imp. L = Improved Leather, Std. T = Standard Tropical, PT = Panama Tropical

TABLE 3

Body Structure Characteristics of Each Platoon Noted During Exam 1

Characteristic		Platoon 1069	1070	1071	1072	Series Total	2069	2070	2071	2072	Series Total	3069	3070	3071	3072	Series Total	Grand Total
Pes planus	no.	18	17	13	17	65	18	24	18	25	85	14	12	10	13	49	199
	%	27.69	25.76	16.46	21.25	22.41	22.78	32.00	22.50	34.72	27.78	17.95	18.46	14.29	18.57	17.38	22.64
Pes cavus	no.	1	1	1	0	3	2	0	1	0	3	1	0	0	1	2	8
	%	1.54	1.52	1.27	0.00	1.03	2.53	0.00	1.25	0.00	0.98	1.28	0.00	0.00	1.43	0.71	0.91
Hallux valgus	no.	1	2	2	4	9	1	0	0	3	4	0	3	3	2	8	21
	%	1.54	3.03	2.53	5.00	3.10	1.27	0.00	0.00	4.17	1.31	0.00	4.62	4.29	2.86	2.84	2.39
Hammertoes	no.	1	0	7	3	11	3	1	0	0	4	0	1	0	2	3	18
	%	1.54	0.00	8.86	3.75	3.79	3.80	1.33	0.00	0.00	1.31	0.00	1.54	0.00	2.86	1.06	2.05
Forefoot adductas	no.	4	0	1	1	6	0	1	0	0	1	0	0	0	0	0	7
	%	6.15	0.00	1.27	1.25	2.07	0.00	1.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.80
Obesity	no.	2	0	2	0	4	2	1	1	1	5	2	1	1	4	8	17
	%	3.08	0.00	2.53	0.00	1.38	2.53	1.33	1.25	1.39	1.63	2.56	1.54	1.43	5.71	2.84	1.93
Tibia varum	no.	1	1	1	1	4	1	1	0	0	2	0	1	0	0	1	7
	%	1.54	1.52	1.27	1.25	1.38	1.27	1.33	0.00	0.00	0.65	0.00	1.54	0.00	0.00	0.36	0.80
Ankle fracture/sprain	no.	3	6	5	1	15	5	2	8	5	20	6	0	6	5	17	52
	%	4.26	9.09	6.33	1.25	5.17	6.33	2.67	10.00	6.94	6.54	7.69	0.00	8.57	5.71	6.03	5.92

TABLE 4

Number of Recruits with Foot Problems within Each Platoon

Problem		Platoon 1069	1070	1071	1072	Series Total	2069	2070	2071	2072	Series Total	3069	3070	3071	3072	Series Total	Grand Total
1. Blister	no.	17	11	22	34	84	18	30	32	27	107	26	22	24	32	104	295
	%	26.15	16.67	27.85	42.50	28.97	22.78	40.00	40.00	37.50	34.97	33.33	33.85	34.29	45.71	36.88	33.56
2. Heel Contusion	no.	20	13	14	9	56	11	7	3	6	27	3	4	7	2	16	99
	%	30.77	19.70	17.72	11.25	19.31	13.92	9.33	3.75	8.33	8.82	3.85	6.15	10.00	2.86	5.67	11.26
3. Clinical Stress	no.	7	3	5	0	15	5	2	6	5	18	0	2	2	4	8	41
	%	10.77	4.54	6.33	0.00	5.17	6.33	2.67	7.50	6.94	5.88	0.00	3.08	2.86	5.71	2.84	4.66
4. Cellulitis	no.	1	3	2	2	8	2	1	3	5	11	2	2	3	4	11	30
	%	1.54	4.54	2.53	2.50	2.76	2.53	1.33	3.75	6.94	3.60	2.56	3.08	4.29	5.71	3.90	3.41
5. Tendinitis	no.	4	4	2	1	11	3	4	1	1	9	1	0	3	2	6	26
	%	6.15	6.06	2.53	1.25	3.79	3.80	5.33	1.25	1.39	2.94	1.28	0.00	4.29	2.86	2.13	2.96
6. Stress Fracture	no.	0	0	2	1	3	0	1	6	2	9	1	1	0	2	4	16
	%	0.00	0.00	2.53	1.25	1.03	0.00	1.33	7.50	2.78	2.94	1.28	1.54	0.00	2.86	1.42	1.82
7. Lace Irritation/ Lesion	no.	12	8	6	7	33	11	10	6	13	40	13	4	3	13	33	106
	%	18.46	12.12	7.60	8.75	11.38	13.92	13.33	7.50	18.06	13.07	16.67	6.15	4.29	18.57	11.70	12.06
8. Ingrown Nail	no.	6	4	3	1	14	1	6	4	1	12	4	1	4	2	11	37
	%	9.23	6.06	3.80	1.25	4.83	1.27	8.00	5.00	1.39	3.92	5.13	1.54	5.71	2.86	3.90	4.21
9. Ankle Sprain	no.	1	0	5	4	10	1	4	3	3	11	6	3	1	5	15	36
	%	1.54	0.00	6.33	5.00	3.45	1.27	5.33	3.75	4.17	3.60	7.69	4.62	1.43	7.14	5.32	4.10
10. Callus	no.	2	1	3	2	8	3	3	3	1	10	2	2	6	2	12	30
	%	3.08	1.52	3.80	2.50	2.76	3.80	4.00	3.75	1.39	3.27	2.56	3.08	8.57	2.86	4.29	3.41

TABLE 4 (cont'd)

Number of Recruits with Foot Problems within Each Platoon

Problem		Platoon 1069	1070	1071	1072	Series Total	2069	2070	2071	2072	Series Total	3069	3070	3071	3072	Series Total	Grand Total
11. Athlete's Foot	no.	1	1	1	1	4	1	1	2	2	6	3	1	0	1	5	15
	%	1.54	1.52	1.27	1.25	1.38	1.27	1.33	2.50	2.78	1.96	3.85	1.54	0.00	1.43	1.77	1.71
12. Anterior Metatarsalgia	no.	0	1	1	0	2	1	0	2	0	3	0	3	2	3	8	13
	%	0.00	1.52	1.27	0.00	0.69	1.27	0.00	2.50	0.00	0.98	0.00	4.62	2.86	4.29	2.84	1.48
13. Retrocalcaneal Bursitis	no.	2	0	2	0	4	2	1	1	0	4	1	0	1	1	3	11
	%	3.08	0.00	2.53	0.00	1.38	2.53	1.33	1.25	0.00	1.31	1.28	0.00	1.43	1.43	1.06	1.25
14. Corn	no.	0	0	2	0	2	0	1	1	0	2	0	0	3	2	5	9
	%	0.00	0.00	2.53	0.00	0.69	0.00	1.33	1.25	0.00	0.65	0.00	0.00	4.29	2.86	1.77	1.02
15. Synovitis	no.	2	1	0	0	3	1	1	1	1	4	0	0	0	0	0	7
	%	3.08	1.52	0.00	0.00	1.03	1.27	1.33	1.25	1.39	1.31	0.00	0.00	0.00	0.00	0.00	0.80
16. Plantar Fasciitis	no.	3	0	1	0	4	0	0	0	0	0	1	0	1	0	2	6
	%	4.62	0.00	1.27	0.00	1.38	0.00	0.00	0.00	0.00	0.00	1.28	0.00	1.43	0.00	0.71	0.68
17. Toe Paresthesia	no.	0	0	0	1	1	0	0	1	0	1	1	1	0	2	4	6
	%	0.00	0.00	0.00	1.25	0.34	0.00	0.00	1.25	0.00	0.33	1.28	1.54	0.00	2.86	1.42	0.68

participants had tendinitis, 3.41% had cellulitis, and 1.82% incurred stress fractures. Clinical stress, ingrown nails, ankle sprains, and calluses were diagnosed in between 3.41 and 4.66% on the recruits (Table 4).

Analyses of Boot Effects

Separate chi-square (χ^2) analyses were performed for each of the foot problems listed in Table 4 to determine whether there was a significant difference in the occurrence of a particular problem as a function of the type and style of boot worn. The data included both cases detected during Exams 2 through 4 and diagnoses made at sick calls. The results of χ^2 tests in which the type of boot was considered, but not its style, are presented in Table 5 together with the number and percentage of men who were diagnosed at least once as having one of the foot problems listed. It should be noted that only those recruits whose Individual Record Sheets indicated that they had received two pairs of leather or two pairs of tropical boots were included in these analyses. As can be seen in Table 5, there was one significant difference attributable to boot type. The number of cases of retrocalcaneal bursitis was significantly greater among recruits wearing the tropical boot than among those issued the leather boot. Two other large, but not significant, differences were found for synovitis and plantar fasciitis. The number of occurrences of both these problems was somewhat greater among those recruits wearing leather boots.

Further analyses were performed in which both type and style of boot were considered. Included here were those men whose Record Sheets indicated that they had been issued two pairs of boots of identical type and style. The results of χ^2 tests performed on these data are presented in Table 6. Significant differences were found in the occurrence of heel contusions, plantar fasciitis, and toe paresthesia. Subsequent detailed comparisons were performed between each boot type and style with regard to these three problems and are presented in Appendix C. The detailed comparisons indicated that the standard tropical yielded a significantly higher proportion of heel contusions than did the other three types and styles of boots and that the latter three did not differ significantly from each other. The proportion of occurrences of plantar fasciitis was significantly greater when the improved leather boot was worn than when either the standard leather or the Panama tropical boots were used. No other comparisons among boots with regard to plantar fasciitis were significant (Appendix C). For toe paresthesia, the standard tropical yielded a significantly greater proportion of cases than did the standard leather or the Panama tropical. There were no other significant differences among boots in the comparisons performed for toe paresthesia (Appendix C).

The analyses of boot type and style yielded additional large, but not significant, differences among the boots with regard to the number of cases of ankle sprain and retrocalcaneal bursitis. All seven cases of the latter occurred among recruits wearing the Panama tropical boot. The highest proportion of ankle sprains occurred when the improved leather was used (Table 6).

TABLE 5

Number of Recruits with Foot Problems as a Function of Type of Boot Worn

Problem	Boot Type: Leather no.	Leather %	Tropical no.	Tropical %	χ^2*	p
(Total Recruits)	(414)	(100)	(372)	(100)	–	–
1. Blister	142	34.30	123	33.06	0.13961	N.S.
2. Heel Contusion	38	9.18	47	12.63	2.42601	N.S.
3. Clinical Stress	21	5.07	17	4.57	0.10757	N.S.
4. Cellulitis	17	4.11	13	3.50	0.19804	N.S.
5. Tendinitis	15	3.62	9	2.42	0.96081	N.S.
6. Stress Fracture	8	1.93	6	1.61	0.11435	N.S.
7. Lace Irritation/ Lesion	44	10.63	48	12.90	0.98143	N.S.
8. Ingrown Nail	19	4.59	15	4.03	0.14182	N.S.
9. Ankle Sprain	20	4.83	14	3.76	0.53588	N.S.
10. Callus	14	3.38	11	2.96	0.11364	N.S.
11. Athlete's Foot	6	1.45	3	0.81	0.73145	N.S.
12. Anterior Metatarsalgia	9	2.17	4	1.08	0.145298	N.S.
13. Retrocalcaneal Bursitis	1	0.24	9	2.42	7.39889	.01
14. Corn	4	0.97	6	1.61	0.65446	N.S.
15. Synovitis	6	1.45	1	0.27	3.08720	N.S.
16. Plantar Fasciitis	4	0.97	0	0.00	3.61265	N.S.
17. Toe Paresthesia	3	0.72	2	0.54	0.11234	N.S.

*df=1

TABLE 6

Number of Recruits with Foot Problems as a Function of Type and Style of Boot Worn

Problem	Boot Type and Style[a] Std. L no.	Std. L %	Imp. L no.	Imp. L %	Std. T no.	Std. T %	PT no.	PT %	χ^2 [b]	p
(Total Recruits)	216	100	91	100	11	100	290	100	–	–
1. Blister	75	34.72	24	26.37	3	27.27	101	34.83	2.64429	N.S.
2. Heel Contusion	19	8.80	8	8.79	4	36.36	34	11.72	9.07357	.05
3. Clinical Stress	9	4.17	4	4.40	0	0.00	13	4.48	0.53111	N.S.
4. Cellulitis	13	6.02	2	2.20	0	0.00	11	3.79	3.22258	N.S.
5. Tendinitis	7	3.24	3	3.30	0	0.00	7	2.41	0.71523	N.S.
6. Stress Fracture	7	3.24	1	1.10	0	0.00	6	2.07	1.75911	N.S.
7. Lace Irritation/ Lesion	30	13.89	8	8.79	1	9.09	34	11.72	1.72529	N.S.
8. Ingrown Nail	9	4.17	4	4.40	1	9.09	9	3.10	1.37137	N.S.
9. Ankle Sprain	8	3.70	9	9.89	1	9.09	11	3.79	7.09291	N.S.
10. Callus	8	3.70	4	4.40	1	9.09	9	3.10	1.33008	N.S.
11. Athlete's Foot	4	1.85	1	1.10	0	0.00	3	1.11	1.01001	N.S.
12. Anterior Metatarsalgia	2	0.93	4	4.40	0	0.00	4	1.38	5.25464	N.S.
13. Retrocalcaneal Bursitis	0	0.00	0	0.00	0	0.00	7	2.41	7.76889	N.S.
14. Corn	2	0.93	1	1.10	0	0.00	5	1.72	3.00000	N.S.
15. Synovitis	2	0.93	2	2.20	0	0.00	1	0.34	3.04663	N.S.
16. Plantar Fasciitis	2	0.93	4	4.40	0	0.00	0	0.00	13.42272	.01
17. Toe Paresthesia	2	0.93	1	1.10	1	9.09	1	0.34	10.15583	.02

[a]Std. L = Standard Leather, Imp. L = Improved Leather, Std. T = Standard Tropical, PT = Panama Tropical

[b]$df = 3$

Relationships among Body Structures and Foot Disorders

During Exam 1, notations were made regarding the presence of such body structural characteristics as obesity, pes planus, forefoot adductus, and pes cavus, together with instances of previous lower extremity disorders. After the completion of testing, conditional probabilities were computed to determine the relationship between a specific structure and the occurrence of foot problems over the course of training. For example, one computation done was the probability of cellulitis given the identification of pes planus. All 879 recruits from whom completed Record Sheets had been received were included in these computations, regardless of the types and styles of boots which they were issued.

The estimated probabilities ($\hat{P}$) are presented in Appendix D along with the 95% confidence interval for each probability. The wide ranges of the majority of confidence intervals are an indication of the low accuracy of the estimated probabilities due to small sample sizes. However, these probabilities were included here as an attempt to establish a data base, subject to further refinements, for prediction of foot problems given the presence of specific body structures and histories of lower extremity problems.

An indication of the relationship between a foot problem and the body structural characteristics may be obtained by contrasting the percentage of recruits having that foot problem (Table 4) with the estimated conditional probabilities obtained involving that problem (Appendix D). In order to test for significance among these relationships, analyses were performed contrasting the presence and absence of a specific foot problem with the presence and absence of a specific body structure. Those which yielded significant results are presented in Table 7. As mentioned previously, the sample sizes being dealt with here are small and should be augmented by additional data for increased accuracy.

The results indicated that pes cavus is negatively related to the occurrence of blisters and pes planus is negatively related to ankle sprain. No blisters were diagnosed among recruits with pes cavus while 33.75% of the recruits without pes cavus had blisters. Of the recruits with pes planus, 1.51% incurred an ankle sprain and 4.85% of those without pes planus had ankle sprains. The remaining significant χ^2 values in Table 7 indicated positive relationships between a body structural characteristic and a foot problem. A significantly greater proportion of the heel contusions, stress fractures, and cases of retrocalcaneal bursitis occurred among recruits with pes cavus than among those without this foot structure. Heel contusions were also significantly and positively related to obesity. Those recruits with recent ankle or foot fractures or a history of chronic ankle sprain experienced 11.54% of the ankle sprains which occurred during training while 3.63% of the recruits without such a history had ankle sprains. Athlete's foot was significantly more common among those with hallux valgus than among those recruits without this foot structure. Of the recruits with pes planus, 2.01% had synovitis while 0.44% of those without pes planus had synovitis. There were significantly more cases of toe paresthesia among those who also had forefoot adductus (14.29%) than among those who did not (0.57%).

TABLE 7

Significant Relationships among Foot Problems and Body Structures

Comparison		no.	%	χ^2*	p
Blister	+ Pes cavus	0	0.00	4.07821	.05
	No Pes cavus	295	33.75		
Heel Contusion	+ Pes cavus	3	37.50	5.56088	.02
	No Pes cavus	96	11.02		
Heel Contusion	+ Obesity	5	29.41	5.71324	.02
	No Obesity	94	10.90		
Stress Fracture	+ Pes cavus	2	25.00	24.27310	.001
	No Pes cavus	14	1.61		
Lace Irritation	+ Ankle fracture/sprain	11	21.15	4.31077	.05
	No Ankle fracture/sprain	95	11.49		
Ankle Sprain	+ Pes planus	3	1.51	4.38650	.05
	No Pes planus	33	4.85		
Ankle Sprain	+ Ankle fracture/sprain	6	11.54	7.79504	.01
	No Ankle fracture/sprain	30	3.63		
Athlete's Foot	+ Hallux valgus	2	9.52	7.83808	.01
	No Hallux valgus	13	1.52		
Retro. Bursitis	+ Pes cavus	1	12.50	8.26649	.01
	No Pes cavus	10	1.15		
Synovitis	+ Pes planus	4	2.01	4.79637	.05
	No Pes planus	3	0.44		
Toe Paresthesia	+ Forefoot adductus	1	14.29	19.26015	.001
	No Forefoot adductas	5	0.57		

*df = 1

Diagnosis, Disposition, and Time of Occurrence of Foot Problems

The data presented above regarding foot disorders reflect total numbers of occurrences and were obtained by summing over sick call and Exams 2, 3, and 4 diagnoses. In order to obtain an estimate of the number of man-hours which medical personnel dedicated to the diagnosis and treatment of foot problems experienced by the recruits who participated in this study, the number of sick calls made for each foot problem are presented in Table 8 and the number of times a problem was identified in the course of Exams 2, 3, and 4 is listed separately. The data for Table 8 were obtained from the Individual Record Sheets and Sick Call Slips of the 879 recruits who completed this study and these data are listed separately for Graduates and for Stragglers and Dropouts (Others). The exam tallies include instances of foot disorders previously diagnosed at sick calls, such as stress fractures. The highest number of sick calls were made for heel contusions (97), followed by blisters (44), cellulitis (31), and ingrown nails (27). Ankle sprains and stress fractures involved 24 and 23 sick call visits, respectively. The grand total of sick call visits for all problems listed in Table 8 was 323 over the course of the days of processing and the twelve weeks of training.

The distribution of sick call visits varied over training. Figure 8 is a plot of the number of visits as a function of processing days (P) and training week. Only the data of the Graduates are included here since only this recruit segment can be assumed to have been following the prescribed training schedule. Each data point in Figure 8 is a total obtained by summing over the foot disorders listed in Table 8. The greatest number of sick call visits occurred during the first three training weeks, with the maximum of 43 being reached during the second training week. This was followed by a decrease in visits and a subsequent increase during the ninth and tenth training weeks. Exams 2, 3, and 4, which were held during the fifth, eighth, and twelth weeks of training, resulted in 215, 221, and 72 foot problems being identified, respectively.

The foot disorders incurred by the recruits varied in their impact on a man's training time. The dispositions of the problems by the medical personnel were such that a man was either permitted to return to his platoon with no restrictions placed on his activities or with a light duty or a bedrest restriction. Light duty involved release from physical training or strenuous drilling. In other cases, hospitalization or temporary assignment to the medical rehabilatation platoon was prescribed. Table 9 is a listing by foot problem of the number of man-days and the form of restricted activity entailed. Recruits with cellulitis and ingrown nails were hospitalized for a total of 46 man-days. One hundred seventy and 49 days were spent in the medical rehabilatation platoon for stress fractures and heel contusions, respectively. There were a total of 487 man-days spent on light duty and 19 man-days of bedrest. Combining over all foot problems and forms of restricted activity, 778 man-days of training were directly affected by foot problems among the 879 recruits in this study.

TABLE 8

Listing of the Number of Sick Call Visits and Foot Exams for Each Foot Problem

Problem	Graduates		Others		Total	
	Exam	Sick Call	Exam	Sick Call	Exam	Sick Call
1. Blister	262	33	40	11	302	44
2. Heel Contusion	11	70	2	27	13	97
3. Clinical Stress	21	14	4	2	25	16
4. Cellulitis	4	24	1	7	5	31
5. Tendinitis	14	10	1	3	15	13
6. Stress Fracture	9	8	4	15	13	23
7. Lace Irritation/ Lesion	92	16	16	2	108	18
8. Ingrown Nail	20	20	6	7	26	27
9. Ankle Sprain	19	21	2	3	21	24
10. Callus	26	4	8	1	34	5
11. Athlete's Foot	10	4	2	0	12	4
12. Anterior Metatarsalgia	9	4	6	0	15	4
13. Retrocalcaneal Bursitis	8	2	1	1	9	3
14. Corn	11	0	0	0	11	0
15. Synovitis	0	6	1	0	1	6
16. Plantar Fasciitis	0	4	1	2	1	5
17. Toe Paresthesia	3	2	0	1	3	3
Total	519	241	95	82	614	323

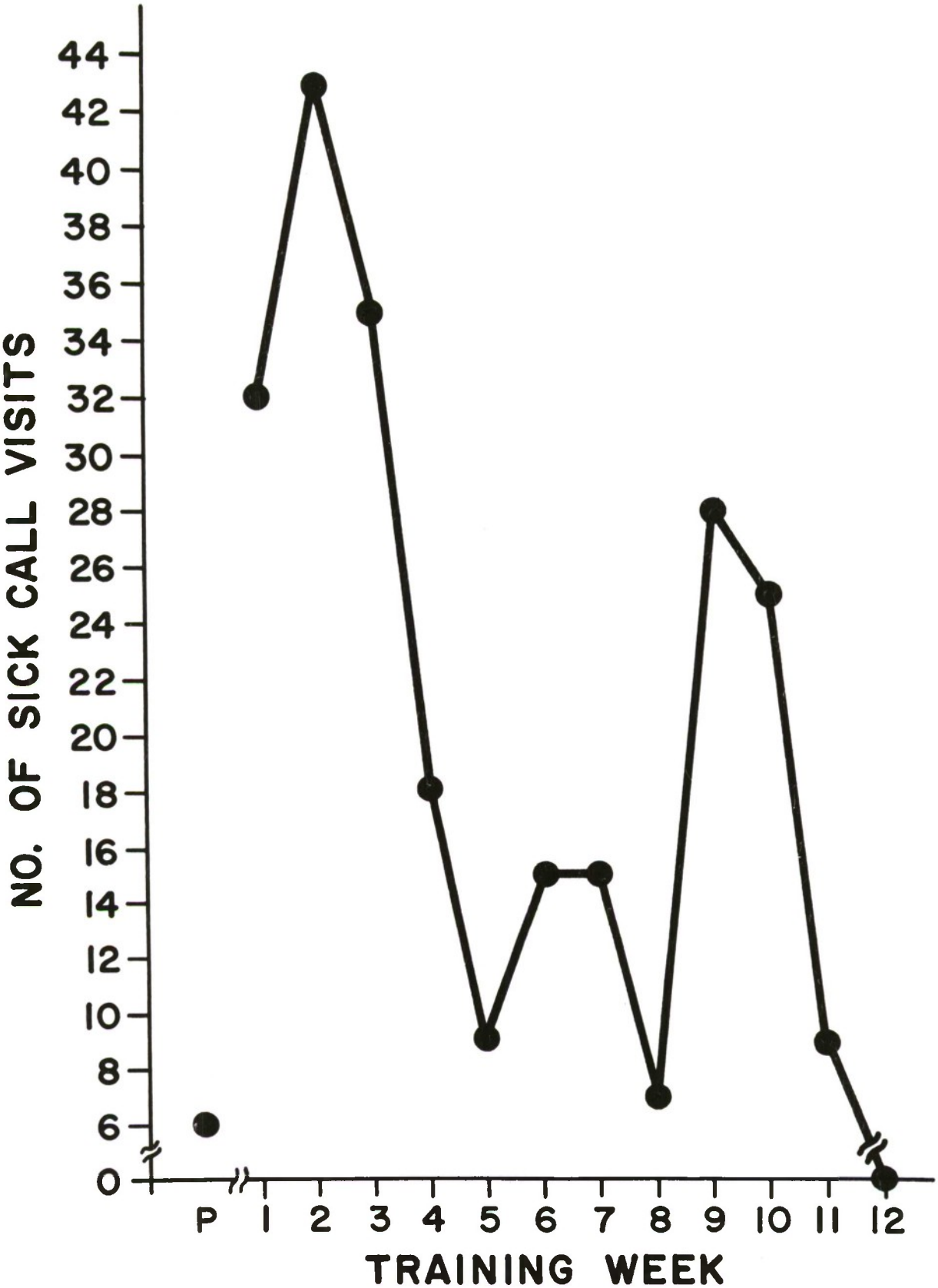

Figure 8. Number of sick call visits made by Graduates during Processing Days (P) and each Training Week

TABLE 9

Number of Man-Days of Restricted Training due to Food Problems

Problem	Hospital	Restriction: Med. Rehab. Platoon	Restriction: Light Duty	Restriction: Bedrest	Total
Blister	0	0	30	2	32
Heel Contusion	0	49	164	2	215
Clinical Stress	0	0	27	3	30
Cellulitis	28	7	50	0	85
Tendinitis	0	0	44	1	45
Stress Fracture	0	170	98	0	268
Ingrown Nail	18	0	32	9	59
Ankle Sprain	0	0	27	2	29
Lace Irritation/Lesion	0	0	4	0	4
Synovitis	0	0	7	0	7
Plantar Fasciitis	0	0	4	0	4
Total	46	226	487	19	778

DISCUSSION AND RECOMMENDATIONS

Of the recruits who completed this study, 37% attended a sick call during their training because of lower extremity disorders. For every 1.13 recruits, one day of training was impacted upon in some way as a result of these disorders. This is in addition to the time spent reporting for sick call. These statements ignore the fact that some recruits never attended sick call for lower extremity disorders, while others did so on more than one occasion, and that the training time of only some men was restricted. However, they do serve as a concise expression of some of the findings of this study. In addition to providing baseline data specific to the Marine Corps recruit situation, these results reinforce previous reports from Army and Navy installations of the high frequency of foot disorders among military trainees (reference 3; reference 9; reference 10). The high number of sick calls within the first three weeks of training is also in accord with the findings of other studies (reference 3), while the subsequent decrease followed by a sharp increase during the ninth and tenth training weeks may be unique to the San Diego Recruit Depot training program.

After approximately three weeks of formal training at the Depot during which physical conditioning and drilling are emphasized, the recruits are transferred to Camp Pendleton where the program is focused upon such activities as rifle qualification and infantry training. During the eighth training week, the recruits are returned to the Depot to complete training with heavy emphasis on drilling and physical conditioning. The bimodal distribution of the number of sick calls as a function of training week reflects the changing emphasis or locations of the training. This distribution is also a reminder that the use of combat boots by new recruits who are unaccustomed to military training is not the only contributor to lower extremity disorders. The contents of the training program are also crucial. It seems that foot disorders can still be precipitated after eight weeks of boot use and daily military exercises given certain training environments.

Up to this point in the discussion, no distinction has been made among the foot disorders of the study participants in terms of frequency of occurrence, number of sick calls for each, or impact on training time. Of course, the different foot problems diagnosed in the present sample of Marine Corps recruits were not equiprobable nor were they equally costly. For example, approximately 14% of the sick calls were made for blisters and 4% of the days of restricted training were for this same problem, whereas stress fractures accounted for 7% of the sick calls and 34% of the restricted training days. Of the 17 foot problems which have been dealt with in this study, only two required hospitalization (cellulitis and ingrown nails) and three involved assignment to the medical rehabilitation platoon (cellulitis, heel contusions, and stress fractures). By far the greatest number of sick calls, over 30%, were made for heel contusions, while eight other foot problems diagnosed among the recruits each represented less than 2% of the sick calls. Consideration of the differences in the frequency and the cost of the various lower extremity disorders

which may arise in a Marine Corps recruit population may help in planning effective strategies for decreasing foot problems among the recruits. Because of the range of disorders and the differences in their etiologies, plans to reduce the occurrence of them all would be difficult to formulate and, probably, not highly successful.

Based upon the results of the present study, it would appear that a decrease in the number of some foot problems could be achieved through a thorough pre-enlistment screening of potential trainees for certain body structural characteristics. The probability that those with a pes cavus foot will develop heel contusions, stress fractures, and retrocalcaneal bursitis during training is significantly higher than it is among those men who do not evidence this particular foot structure. Men who have a history of chronic or recent ankle sprain or a recent ankle or foot fracture are more likely to incur an ankle sprain during training than those who do not have such a history. There were a number of other body structural characteristics which were also found to be signiflcantly related to lower extremity disorders in this experiment and which could serve as input to the decision process in the evaluation of Marine Corps candidates. In addition, the conditional probabilities presented in this report, if further refined, can be used as tools to predict the probability of a particular foot disorder given the presence of a specific body structure. Further collection of these types of data would improve the accuracy of prediction and narrow the ranges of the confidence intervals.

In addition to the screening of candidates, another approach for reducing the occurrence of foot disorders among recruits is embodied in the principal purpose of this study, which was to investigate the effects of the use of tropical versus leather combat boots on the occurrence of foot disorders. However, based upon the analyses performed, there was no indication that the wearing of tropical combat boots by the Marine Corps recruits reduced the number of cases of foot disorders compared to the number occurring when leather combat boots were worn. In fact, the occurrences of some types of foot problems were significantly increased through the use of the tropical boot. Therefore, although the effects of wearing these different types and styles of combat boots were evaluated successfully in this experiment, the hypothesized reductions in the frequencies of certain foot disorders through the use of tropical boots were not obtained. In an effort to gain as much information as possible from those relationships between boots and foot problems that were found to be significant, an attempt will be made to analyze the physical characteristics of the boots tested that may have impacted upon these foot disorders.

Heel contusions, toe paresthesia, and retrocalcaneal bursitis were significantly increased through the use of tropical boots. The latter was associated with the Panama tropical and the two remaining disorders with the standard tropical boot. Unfortunately, only 11 men received two pairs of the standard tropical boots which raises the question of whether or not the statistically significant findings involving this type and style of boot

would be replicated if a larger sample of these boots was introduced into a study such as this one. However, the fact remains that four of the recruits who wore the standard tropical boot, or 36.4%, were diagnosed as having heel contusions, while the rate of occurrence with the other three types and styles ranged from approximately 8.8% for the leather to 11.7% for the Panama tropical. None of the recruits who were issued the standard tropical boot had been diagnosed as being obese or having a pes cavus foot, the two body structures significantly related to heel contusions. Therefore, given that all recruits had the same standard training, the high percentage of heel contusions among those wearing the standard tropical boot would seem to be attributable to the boot itself.

The heel area of the standard tropical differs from those of the leather boots in sole tread design and in the presence of the steel plate in the tropical, while it differs from the Panama tropical only with regard to sole design. Since there were no significant differences between the Panama tropical and the leather boots with regard to heel contusions, although the percentage of cases when Panama tropical boots were worn was slightly higher, it does not seem likely that the steel plate itself was responsible for the heel contusions. This leaves sole tread design as the potent variable. As can be seen in Figure 2, the standard tropical boot has a more solid tread in the heel area than does the Panama tropical with its large gaps between treads. The heel tread of the standard has been found to entrap pebbles, clay, mud, and other debris (reference 19). Entrapped debris, combined with the steel plate, may have provided a hard surface which precipitated the heel contusions.

The other disorder associated with the standard tropical boots, toe paresthesia, occurred in one recruit or 9.1% of the men wearing these boots, while the percentages of cases among the other three types and styles of boots were not greater than 1.1%. Although, on the basis of the χ^2 tests, the standard tropical boot yielded a significantly higher number of cases of toe paresthesia than did either the standard leather or the Panama tropical boots, this finding is of limited practical significance because of the small number of standard tropical boots tested and the occurrence of toe paresthesia in only one of the recruits wearing these boots.

The third foot disorder found to be significantly increased by use of the tropical boots was retrocalcaneal bursitis. When boot type, but not style, was considered, there were significantly more cases of bursitis with the tropical than with the leather boot. When style, as well as type of boot, was analyzed, the differences in the numbers of cases were large, but not statistically significant, with bursitis occurring only when the Panama tropical boot was worn.

A χ^2 test was performed to determine whether there was a higher incidence of the pes cavus foot among the recruits issued either of the tropical boots than among those wearing the leather boots. This analysis was performed because of the relationship obtained

between pes cavus and retrocalcaneal bursitis. The results did not indicate any differences in the number of cases of pes cavus among the four boot groups, χ^2 (3)= 4.08533. Therefore, the bursitis would seem to be attributable to the design of the Panama tropical boot itself, specifically the lower part of the back. Since the Panama does not differ from the standard tropical boot in this area and no cases of retrocalcaneal bursitis occurred with the latter, there is no obvious physical feature of the boot with which the bursitis may be linked. However, because of the small number of standard tropical boots involved in this study, it would be premature to conclude that bursitis may not be related to the standard tropical as well.

Before dismissing the topic of retrocalcaneal bursitis as related to tropical boots for lack of an obvious cause of the problem, it would seem appropriate to state the physical differences in the counter areas of the tropical and the leather boots. The counter areas of both types of boots are comprised of three distinct layers of material. For the tropical boot, the inner layer is grain-in leather. The next layer is the counter itself made of leatherboard, a rather flexible material, and the outer layer is grain-out leather. The inner layer of the leather boot is grain-out leather and the counter is rigid cellulose shoeboard. The outer layer is grain-out leather. Leatherboard has a history of becoming very flexible and somewhat shapeless with use, especially if exposed to moisture, whereas cellulose shoeboard retains its rigidity (Note 2).

The tropical and the leather boots also differ at the back immediately above the counter. The improved leather boot has no seam here since the backstay and the outer layer of leather covering the counter are one, continuous piece of leather. The standard leather boot has a horizontal seam above the counter which indicates the end of the leather backstay. The seam of the tropical boot indicates the end of the canvas backstay, the end of the canvas upper, and the beginning of the grain-in leather, which is the inner layer lining the counter. The flexibility of the canvas backstay and upper tends to allow the leather immediately above the counter to curve toward the ankle while this area of the leather boots is relatively vertical.

These are the physical differences in the counter areas of the boots tested. It cannot be determined on the basis of this study whether any of these characteristics may affect the amount of pressure placed on the posterior surface of the calcaneus by the back of the boot and thus contribute to the probability of retrocalcaneal bursitis.

The only other foot disorder significantly affected by the type and style of boot worn was plantar fasciitis which was diagnosed among four, or 4.4%, of the recruits using

---

Note 2: Swain, D. S. Personal communication, March 1, 1976.

the improved leather boot. No cases occurred among those recruits who wore the tropical boots, while two (0.93%) were diagnosed among the users of the standard leather boot. In assessing characteristics of the boots which may have contributed to this significant effect, it seems reasonable to look at aspects which may affect pronation in the area of the foot's longitudinal arch. There are differences in the lower sides of the tropical and the leather boots. Even the two styles of leather boots are not identical. For the leather boots, the relationships between the two side seams and between these seams and the boot heel are different. The standard leather seams are closer to each other and are more anterior relative to the boot heel than those of the improved boot. This configuration of the standard leather boot may serve to keep the bottom of the foot more closely aligned with the sole of the boot than does that of the improved leather. The same function might be served on the tropical boot by the single side seam which is well forward of the heel.

To summarize this discussion of the effects of combat boot types and styles on the occurrence of lower extremity disorders, those few foot problems significantly affected were related to the tropical boots, with one exception. The tropical boots did not result in a decrease in the levels of cellulitis or tendonitis, as had been hypothesized. The latest version of the leather combat boot, the improved leather, did not significantly lower the incidences of foot problems relative to the other types and styles of boots studied here. The discussions presented above regarding the relationships among foot disorders and boot characteristics underline how difficult it is to correlate a particular foot disorder with a specific boot configuration, even when boots that vary somewhat systematically from each other are studied, as they were here.

In considering these findings regarding boot types and styles, it should be realized that, in this study, the use of the tropical boot was extended far beyond the particular environment for which the boot was designed. Its characteristics evolved from requirements for footwear to be used in tropical climates which was well-ventilated, mildew resistant, quick-drying, and spike resistant. Based upon the comments of men who used the tropical boot in Southeast Asia and elsewhere, the functional characteristics of the boot are highly satisfactory (reference 18) and the results of the present study do not contradict this. The gravel, macadam, and hard-packed clay surfaces of the San Diego Recruit Depot provided an environment very different from that for which the tropical boot was developed, as did its use in drilling and physical training. However, this footwear was tested among the Marine Corps recruits to determine whether or not, because of certain design features, its use would result in a reduction of lower extremity disorders among the recruits. This study did not entail any evaluation of the tropical boot with regard to its acceptability in fulfilling the specific functions for which it was developed.

Among the combat boots used by the Marine Corps recruits in this study, the standard leather appeared to be the best in terms of the frequency of foot problems. Improvements in this or any other existent combat boot in order to decrease foot disorders among the

recruits would be minimal if modifications were limited to the application of design configurations employed in the combat boots today. An improved combat boot is not an impossibility, that is a boot that fulfills the functional requirements as well as one that will yield fewer lower extremity disorders, but it would seem that the key to such improved footwear lies in the development and testing of new concepts, not in the manipulation of those used today.

The results of the present study provide baseline data for such a footwear development effort and also document the magnitude and complexity of lower extremity disorders among Marine Corps recruits. Significant progress in decreasing the number of foot problems will not be made by focusing all remedial efforts on a single potent variable, such as footwear or candidate screening, but rather by employing a multifaceted attack. This approach should consider footwear as a complex system, recruit training as a physically stressful environment, and the recruit as the individual who must be taught proper foot care in order to interact successfully with both.

REFERENCE NOTES

1. Gilbert, R. S. Personal communication, December 16, 1974.

2. Swain, D. S. Personal communication, March 1, 1976.

3. Scott, K. Personal communication, February 11, 1976.

4. George, C. R. Personal communication, February 3, 1976.

REFERENCES

1. Moxness, B. A. Military medicine and care of the war disabled to World War I. *Military Medicine*, 1956, **121**, 180–181.

2. Bell, L. G., Shalgren, L. H., and Sheren, B. D. Frostbite in Korean casualties. *US Armed Forces Medical Journal*, 1952, 35–40.

3. Delany, H. M. and Travis, L. O. A clinical evaluation of one hundred cases of infection of the lower leg and foot in military personnel. *Military Medicine*, 1965, **130**, 1184–1190.

4. Lanham, R. H. Stress fractures in military personnel. *Journal of the American Podiatry Association*, 1963, **53**, 192–195.

5. Allen, T. S. Stress fractures. *Texas Medicine*, 1972, **68**, 125–128.

6. MacDonald, R. G. Early diagnosis and treatment of stress fractures of the calcaneus. *Journal of the American Podiatry Association*, 1966, **56**, 533–536.

7. O'Donnell, T. Medical problems of recruit training: A research approach. *US Navy Medicine*, 1971, **58**, 28–34.

8. Gilbert, R. S. and Johnson, H. A. Stress fractures in military recruits – A review of twelve years' experience. *Military Medicine*, 1966, **131**, 716–721.

9. Hockstein, E. S. The role of the podiatrist in the Naval Service. *Journal of the American Podiatry Association*, 1961, **51**, 488–492.

10. Schnitzer, J. S. and Hoeffler, D. F. The distribution and etiology of foot disorders in a Navy recruit population. *Journal of the American Podiatry Association*, 1974, **64**, 845–853.

11. Perkins, J. C. "Joint US Marine Corps, US Army Test of Standard USMC Combat Boots in USMC Tariff, Standard USA Combat Boots in Army Tariff, and USMC and USA Combat Boots Made over Fort Knox V Last in Reduced Tariff." Fort Lee, Virginia: Quartermaster Field Evaluation Agency, June 1961. Tech. Report T–192.

12. Potter, W. A. Report on Department of Defense research project relative to combat boots made over a new type of last. *Journal of the American Podiatry Association*, 1961, **51**, 493–497.

REFERENCES (cont'd)

13. Allen, V. L. and McGinnis, J. M. "Subjective Evaluation of the Schwartz Principle in Army Combat Boots." Natick, MA: Quartermaster Research and Development Center, January 1957. Research Study Report PB–8.

14. Perkins, J. C. "A Field Test of Boots, Service, Combat, Russet, T55–11 and T55–12, Built over Fort Knox V Lasts, Type A and Type B." Fort Lee, Virginia: Quartermaster Field Evaluation Agency, April 1956. Tech. Report 55007–F.

15. Perkins, J. C. "A Field Test of Boots, Service, Combat, Black, T55–11 and T55–12." Fort Lee, Virginia: Quartermaster Field Evaluation Agency, November 1958. Tech. Report T–88.

16. Ulmer, D. D. and Stein, S. W. "Medical Report of Study of Boots, Service, Combat, Black, T55–11 and T55–12, Built over Fort Knox V Lasts." Fort Knox, Kentucky: US Army Medical Research Laboratory, January 1958. Tech. Report MEDEA–RD–58–37.

17. Potter, W. A. Final report on Department of Defense research project relative to combat boots made over a new type of last. *Journal of the American Podiatry Association*, 1962, 52, 122–125.

18. Park, A. F. and Swain, D. S. "Direct Molded Sole Boots." Natick, MA: US Army Natick Laboratories, September 1967. Tech. Report 68–20–CM.

19. Sims, C. "Service Test of Boot, Combat, Tropical, DMS with Spike Resistant Sole Shield." Fort Clayton, Canal Zone: US Army Tropic Test Center, August 1966. USATECOM Project No. 8–6–6010–01.

20. Gius. *Fundamentals of General Surgery*. Chicago: Year Book Medical Publishers, 1966.

21. Hoerr, N. L. and Osol, A. (Eds.). *Blakiston's New Gould Medical Dictionary*. New York: McGraw-Hill Book Co., 1956.

22. *Dorland's Illustrated Medical Dictionary* (24th Edition). Philadelphia: W. B. Saunders Co., 1965.

23. Gartland. *Fundamentals of Orthopaedics*. Philadelphia: W. B. Saunders Co., 1969.

APPENDIX A

Descriptions of Lower Extremity Disorders Cited in Study

ACHILLES TENDINITIS – See TENDINITIS

ANTERIOR METATARSALGIA – A term used to indicate a complaint of burning and soreness across the plantar aspects of some or all of the five metatarso-phalangeal joints of the toes. This is due to the shearing force that occurs on abnormal weight transfer across these segments (Note 3).

CELLULITIS – An acute inflammatory reaction which extends along connective tissue planes and across intercellular spaces. There is widespread swelling and redness, without definite localization and with little or no pus formation. The classic picture of a spreading cellulitis is the result of invasive streptococci. The zone of infection is fiery red, hot, swollen, painful, and extremely tender. There may be no definite line of demarcation. In the more severe infections of this type, blebs and bullae form on the skin. Later there may be necrosis with abscess formation. Nonoperative treatment is used unless localization and abscess formation occurs, at which time incision and drainage of the pus would be indicated.[20] One of the more common sites of cellulitis among the Marine Corps recruits at San Diego is the back of the ankle in the Achilles region of the foot (Note 1).

CLINICAL STRESS FRACTURE – A term used to describe a part that has all the clinical symptoms of a stress fracture, but radiological findings are negative for fracture (Note 3). As used in this study, the term denotes clinical stress of the metatarsals or distal aspects of the fibula and tibia. Clinical stress of the calcaneus is referred to as a heel contusion.

FOREFOOT ADDUCTUS – The pointing of the anterior part of the foot toward the median line of the body.[21]

Note 3: Scott, K. Personal communication, February 11, 1976.

[20] Gius. *Fundamentals of General Surgery.* Chicago: Year Book Medical Publishers, 1966.

[21] Hoerr, N. L. and Osol, A. (Eds.) *Blakiston's New Gould Medical Dictionary.* New York: McGraw-Hill Book Co., 1956.

HALLUX VALGUS – Angulation of the great toe (hallux) away from the midline of the body, or toward the other toes (reference 21).

HAMMERTOES – A condition of the toe in which the proximal phalanx (i.e., toe bone closest to the body of the foot) is extremely extended while the distal phalanges are flexed (reference 21).

HEEL CONTUSION – As used in this study, the term denotes a clinical stress fracture of the calcaneus with negative radiological findings.

LACE IRRITATION/LESION – A friction or pressure lesion on the skin, particularly the anterior ankle area, due to boot lace or eyelet pressure on the extensor tendons (Note 3).

METATARSALGIA – See ANTERIOR METATARSALGIA

PES CAVUS – Exaggerated height of the longitudinal arch of the foot.[22]

PES PLANUS – A depression of the longitudinal arch of the foot (reference 21).

PLANTAR FASCIITIS – Inflammation and minute tearing of the dense fibrous tissues of the bottom of the foot which run longitudinally from heel to toes. Parts of the tissue are exposed to stretching and to strain when excessive pronation occurs below the talus in the area of the foot's longitudinal arch (Note 3).

RETROCALCANEAL BURSITIS – An inflammatory response of one particular bursa located between the calcaneus and the Achilles tendon. It is usually attributable in part to chronic pressure between the posterior facet of the calcaneus and the back of footwear (Note 3).

STRESS FRACTURE – These are also referred to as fatigue or march fractures. They are due to repeated, rhythmic, submaximal insults on a bony structure until it weakens and bone destruction is noted radiographically. Radiographs may not show destruction until one to four weeks after symptoms first arise. The clinical picture usually includes a history of strenuously using the part for many days with edema and point tenderness directly over the bony part involved. The bones most often involved include metatarsals, the distal aspects of the fibula and tibia, and the calcaneus (Note 4). In this study,

---

[22] *Dorland's Illustrated Medical Dictionary* (24th Edition). Philadelphia: W. B. Saunders Co., 1965.

Note 4: George, C. R. Personal communication, February 3, 1976.

the term stress fracture is used to denote positive radiographical identification of destruction of a bone in the foot or the lower leg. No distinction is made as a function of the bone involved.

SYNOVITIS – Inflammation of a synovial membrane with fluctuating swelling (reference 21).

TENDINITIS (ACHILLES) – Traumatic or mechanical irritation of the Achilles tendon or tendon sheath which gives rise to a locally painful, noninfectious inflammation of this part. This problem is usually caused by local trauma, some mechanical malalignment of the part, or as a complication following strenuous or unaccustomed use of the part. The condition may be painful and usually responds to heat, rest through immobilization, and, where applicable, local injections of hydrocortisone.[23]

TIBIA VARUM – Bowing of the leg in which angulation is toward the midline of the body (reference 22).

TOE PARESTHESIA – Morbid or abnormal sensation in the toes (reference 21).

---

[23] Gartland. *Fundamentals of Orthopaedics.* Philadelphia: W. B. Saunders, 1969.

APPENDIX B

SAMPLES OF DATA ACQUISITION FORMS

APPENDIX B (cont'd)

INDIVIDUAL RECORD SHEET

Name: _____

Pltn: _____

1st Boot Type: Trop. Leather **2nd Boot** Type: Trop. Leather

Size: _____ Size: _____

Sick Call

	Date	Diagnosis	Disposition
A.			
B.			
C.			
D.			
E.			
F.			

Foot Exams	**1**	**2**	**3**	**4**
(Sign Off)				
Cellulitis				
Tendinitis (Achilles)				
Heel Contusions				
Stress Fracture (Pos X-ray)				
Clinical Stress				
Other:				
Comments:				

Graduated
Date: _____

Transferred
Date: _____
Reassignment: _____

Dropped
Date: _____
Reason: _____

APPENDIX B (cont'd)

Sick Call Stamp

_____ Cellulitis

_____ Tendinitis (Achilles)

_____ Heel Contusions

_____ Stress Fracture (Pos X-ray)

_____ Clinical Stress

_____ Other:

Comments:

APPENDIX C

Detailed Comparisons among Boot Types and Styles

Comparison[a]		Heel Contusion		Plantar Fasciitis		Toe Paresthesia	
		χ^2 b	p	χ^2	p	χ^2	p
Std. L vs	Imp. L	<1.00000	N.S.	4.02505	.05	<1.00000	N.S.
	Std. T	8.73583	.01	<1.00000	N.S.	5.34636	.05
	PT	1.13168	N.S.	2.70229	N.S.	<1.00000	N.S.
Imp. L vs	Std. T	7.18721	.01	<1.00000	N.S.	3.25949	N.S.
	PT	<1.00000	N.S.	12.88162	.001	1.66412	N.S.
Std. T vs	PT	5.83286	.02	<1.00000	N.S.	12.28485	.001

[a]Std. L = Standard Leather, Imp. L = Improved Leather, Std. T = Standard Tropical, PT = Panama Tropical

[b]df = 1

APPENDIX D

Estimated Conditional Probabilities ($\hat{P}$) and 95% Confidence Intervals for Body Structure and Foot Problem Relationships

Probability of	Given	c/n*	$\hat{P}$	95% Confidence Interval
1. Blister	Pes planus	69/199	0.347	$0.275 \leq P \leq 0.425$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	6/21	0.286	$0.110 \leq P \leq 0.525$
	Hammertoes	5/18	0.278	$0.090 \leq P \leq 0.475$
	Forefoot adductus	3/7	0.429	$0.100 \leq P \leq 0.875$
	Obesity	4/17	0.235	$0.060 \leq P \leq 0.500$
	Tibia varum	2/7	0.286	$0.035 \leq P \leq 0.700$
	Ankle fracture/sprain	13/52	0.250	$0.140 \leq P \leq 0.390$
2. Heel Contusion	Pes planus	23/199	0.116	$0.060 \leq P \leq 0.175$
	Pes cavus	3/8	0.375	$0.075 \leq P \leq 0.775$
	Hallux valgus	2/21	0.095	$0.010 \leq P \leq 0.305$
	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.200$
	Forefoot adductus	1/7	0.143	$0.005 \leq P \leq 0.580$
	Obesity	5/17	0.294	$0.100 \leq P \leq 0.550$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.600$
	Ankle fracture/sprain	6/52	0.115	$0.025 \leq P \leq 0.700$
3. Clinical Stress	Pes planus	10/199	0.050	$0.025 \leq P \leq 0.125$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
	Hammertoes	2/18	0.111	$0.015 \leq P \leq 0.345$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	1/17	0.059	$0.000 \leq P \leq 0.285$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	2/52	0.038	$0.000 \leq P \leq 0.100$
4. Cellulitis	Pes planus	7/199	0.035	$0.025 \leq P \leq 0.100$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	1/21	0.048	$0.000 \leq P \leq 0.240$
	Hammertoes	2/18	0.111	$0.015 \leq P \leq 0.345$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	1/17	0.059	$0.000 \leq P \leq 0.285$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	1/52	0.019	$0.000 \leq P \leq 0.075$

APPENDIX D (cont'd)

Probability of	Given	c/n*	$\hat{P}$	95% Confidence Interval
	Pes planus	7/199	0.035	$0.025 \leq P \leq 0.100$
	Pes cavus	1/8	0.125	$0.005 \leq P \leq 0.525$
	Hallux valgus	1/21	0.048	$0.000 \leq P \leq 0.240$
5. Tendinitis	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	1/7	0.143	$0.005 \leq P \leq 0.580$
	Obesity	1/17	0.059	$0.000 \leq P \leq 0.285$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	1/52	0.019	$0.000 \leq P \leq 0.075$
	Pes planus	2/199	0.010	$0.010 \leq P \leq 0.050$
	Pes cavus	2/8	0.250	$0.030 \leq P \leq 0.650$
	Hallux valgus	1/21	0.048	$0.000 \leq P \leq 0.240$
6. Stress Fracture	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	0/52	0.000	$0.000 \leq P \leq 0.075$
	Pes planus	23/199	0.090	$0.060 \leq P \leq 0.175$
	Pes cavus	2/8	0.250	$0.030 \leq P \leq 0.650$
	Hallux valgus	2/21	0.095	$0.010 \leq P \leq 0.305$
7. Lace Irritation/	Hammertoes	2/18	0.111	$0.015 \leq P \leq 0.345$
Lesion	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	11/52	0.055	$0.010 \leq P \leq 0.150$
	Pes planus	6/199	0.030	$0.020 \leq P \leq 0.075$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
8. Ingrown Nail	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	1/17	0.059	$0.000 \leq P \leq 0.285$
	Tibia varum	1/7	0.143	$0.005 \leq P \leq 0.580$
	Ankle fracture/sprain	2/52	0 038	$0.000 \leq P \leq 0.100$

APPENDIX D (cont'd)

Probability of	Given	c/n*	$\hat{P}$	95% Confidence Interval
9. Ankle Sprain	Pes planus	3/199	0.015	$0.010 \leq P \leq 0.050$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	6/52	0.115	$0.025 \leq P \leq 0.700$
10. Callus	Pes planus	5/199	0.025	$0.010 \leq P \leq 0.050$
	Pes cavus	1/8	0.125	$0.005 \leq P \leq 0.525$
	Hallux valgus	1/21	0.048	$0.000 \leq P \leq 0.240$
	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	1/52	0.019	$0.000 \leq P \leq 0.075$
11. Athlete's Foot	Pes planus	2/199	0.010	$0.010 \leq P \leq 0.050$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	2/21	0.095	$0.010 \leq P \leq 0.305$
	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	1/52	0.019	$0.000 \leq P \leq 0.075$
12. Anterior Metatarsalgia	Pes planus	3/199	0.015	$0.010 \leq P \leq 0.050$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
	Hammertoes	1/18	0.056	$0.000 \leq P \leq 0.275$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	1/52	0.019	$0.000 \leq P \leq 0.075$

APPENDIX D (cont'd)

Probability of	Given	c/n*	$\hat{P}$	95% Confidence Interval
	Pes planus	1/199	0.005	$0.005 \leq P \leq 0.050$
	Pes cavus	1/8	0.125	$0.005 \leq P \leq 0.525$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
13. Retrocalcaneal	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
Bursitis	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	0/52	0.000	$0.000 \leq P \leq 0.075$
	Pes planus	2/199	0.010	$0.010 \leq P \leq 0.050$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
14. Corn	Hammertoes	1/18	0.056	$0.000 \leq P \leq 0.272$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	0/52	0.000	$0.000 \leq P \leq 0.075$
	Pes planus	4/199	0.020	$0.020 \leq P \leq 0.060$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
15. Synovitis	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	1/52	0.019	$0.000 \leq P \leq 0.075$
	Pes planus	2/199	0.010	$0.010 \leq P \leq 0.050$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
16. Plantar	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
Fasciitis	Forefoot adductus	0/7	0.000	$0.000 \leq P \leq 0.410$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	0/52	0.000	$0.000 \leq P \leq 0.075$

APPENDIX D (cont'd)

Probability of	Given	c/n*	P̂	95% Confidence Interval
17. Toe Paresthesia	Pes planus	2/199	0.010	$0.010 \leq P \leq 0.050$
	Pes cavus	0/8	0.000	$0.000 \leq P \leq 0.365$
	Hallux valgus	0/21	0.000	$0.000 \leq P \leq 0.165$
	Hammertoes	0/18	0.000	$0.000 \leq P \leq 0.185$
	Forefoot adductus	1/7	0.143	$0.005 \leq P \leq 0.580$
	Obesity	0/17	0.000	$0.000 \leq P \leq 0.195$
	Tibia varum	0/7	0.000	$0.000 \leq P \leq 0.410$
	Ankle fracture/sprain	1/52	0.019	$0.000 \leq P \leq 0.075$

*c = no. of recruits having both; n = no. of recruits having the latter.